SWRHL-7r

FINAL REPORT OF OFF-SITE SURVEILLANCE FOR THE KIWI B4D EXPERIMENT

by the
Off-Site Radiological Safety Program
Southwestern Radiological Health Laboratory
Las Vegas, Nevada

for
Operational Safety Division
Nevada Operations Office
Atomic Energy Commission

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Public Health Service

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ABSTRACT

The Public Health Service provided off-site surveillance in support of the KIWI B4D reactor tests conducted on May 8 and May 13, 1964. This support consisted of tracking the effluent, monitoring radiation dosage to the off-site population, and collecting environmental samples (air, milk, and water). The data collected indicate that no hazard to the off-site population was created as a result of the KIWI tests.

KIWI B4D TEST

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I. INTRODUCTION

On May 8, and May 13, 1964 the KIWI B4D reactor was tested at Test Cell C, located at the Nuclear Rocket Development Station, Jackass Flats, Nevada. The May 8 experiment was an intermediate power run (design power x 0.001) and was a scaled down profile of the full power test conducted on May 13 The tests were part of a series presently being conducted by the Los Alamos Scientific Laboratory to achieve a workable design for space vehicle use. During the full power test, the reactor was brought to design power at 1045 hours and remained at that level for sixty-four seconds. The reactor was tested in an upright position so that the hydrogen coolant exhausted upward along with escaping fission products.

Under a Memorandum of Understanding between the U.S. Atomic Energy Commission (AEC) and the U.S. Public Health Service (PHS), the Off-Site Radiological Safety Organization was established in 1954 to conduct radiological surveillance of the area within a 300-mile radius surrounding the Commission's Nevada Test Site. A Commissioned Officer of the Public Health Service was designated by the AEC as Off-Site Radiological Safety Officer, and was responsible to the Test Manager for directing the surveillance activities.

Since that time, the PHS has established in Las Vegas, Nevada its Southwestern Radiological Health Laboratory (SWRHL). The off-site surveillance of activities at the Nevada Test Site and of other nuclear events conducted by the Nevada Test Site Organization has become one

of the Laboratory's regular operational programs. The Officer in Charge of the Laboratory serves as Off-Site Radiological Safety Officer to the Operational Safety Division, Nevada Operations Office.

The off-site area in which the Off-Site Radiological Safety Program of SWRHL conducts its program of radiological monitoring and environmental sampling was re-defined after the end of the test moratorium in 1961 to consist of the area surrounding the Nevada Testing and Bombing and Gunnery Range Complex. This Complex includes the Nevada Test Site (NTS), the Nuclear Rocket Development Station (NRDS), the Tonopah Test Range, and the Nellis Bombing and Gunnery Range, and for simplicity, will be called the test range complex throughout this report.

A memorandum from B. P. Helgeson, Chief, Space Nuclear Propulsion Office-Nevada, to N. H. Woodruff, Director Division of Operational Safety, AEC, April 24, 1963 deals with "NRDS Safety Responsibilities". This points out that off-NRDS areas remain the responsibility of the Manager, NVOO, AEC, and through the Operational Safety Division, NVOO, remain the responsibility of the Public Health Service.

Although Public Health Service monitors must begin tracking and monitoring an effluent cloud close to its point of origin, the measurements made within the test range complex are used only as a guide to trajectory determination, or for purposes of checking instrumentation and methodology. Since they do not serve as parameters in determining dose to people or contamination of property in the off-site area, they are not a subject of this report.

II. OPERATIONAL PROCEDURES

A. EXTERNAL MEASUREMENTS

By Ground Monitors

Fourteen ground monitors tracked the reactor effluent passage with portable instruments. Each monitor was equipped with the following monitoring instruments: an Eberline E-500B, a Precision Model 111 Standard "Scintillator", a Beckman MX-5, and a Tracerlab AN/PDR T1B.

The Eberline E-500B has a range of 0-200 milliroentgens per hour (mr/hr) gamma and beta-gamma detection in four scales with an external halogen filled G M tube and a 0-2000 mr/hr range from an internal Anton 302 tube. The Precision Model 111 "Scintillator" is used primarily for low level detection and provides for a range of 0-5 mr/hr in six scales. The Beckman MX-5 instrument has a range of 0-20 mr/hr in three scales. It is equipped with an external geiger tube with a slide-open beta shield. The Tracerlab AN/PDR T1B has a range of 0-50,000 mr/hr in five scales. This instrument employs an air ionization chamber detector. These instruments are accurate to ±20%, and readings can be taken to only two significant figures.

By Remote Dose Rate Recorders

Eberline RM-11 dose rate recorders are placed at sixteen stations around the Nevada Test Site. These recorders utilize a geiger tube detector to document radiation levels at specific locations. The instrument operates on 110V AC and has a 0.01-100 mr/hr range. Gamma

dose rate is recorded on a 30-hour strip chart. The instrument is accurate to ±20%. The locations of dose rate recorders and areas monitored are presented in Figure 1.

By Cloud Tracking Airplane

An Air Force U3-A aircraft, manned by two Public Health Service monitors equipped with portable instruments identical to those of the ground monitors, tracked the reactor effluent and served to position ground monitors.

By Film Badges

The PHS maintains 65 film badge stations off the test range complex and assigns badges to 166 off-site residents. The badge used is made up of Dupont Type 555 film. Dose, as determined from this film, is accurate to ±50% in the 20-100 mr range and ±10% in the 100-2000 mr range.

B. ENVIRONMENTAL MEASUREMENTS

Air Samples

On the test day the PHS maintained General Metal Works high volume air samplers containing glass fiber prefilters and MSA* charcoal filters at off-site locations as shown in Figure 2. These include 33 routinely operated stations and several additional stations that were established in the path of the effluent on the test day. Analyses of the glass fiber prefilters and the charcoal filters gave the results indicated in Table 4. All air sample prefilters collected following the KIWI reactor runs were returned to Las Vegas to be counted for gross beta activity with a thin window, large area gas flow proportional probe connected to

*Mine Safety Appliance Company

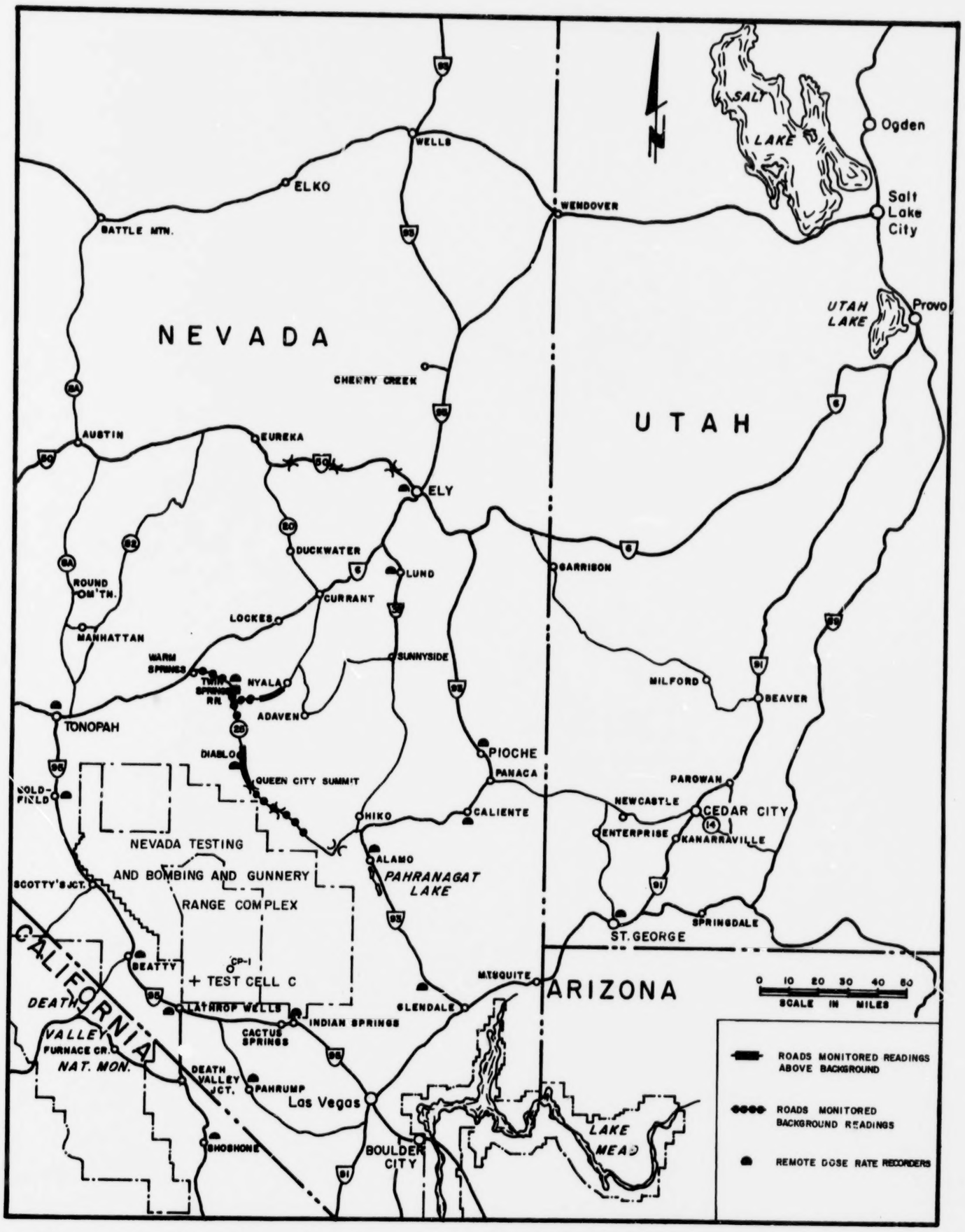

Figure 1. Location of dose rate measurements made following the KIWI B4D test - May 13, 1964.

a high speed scaler. The system is designed to count the 8"x 10" glass fiber filter and has an efficiency of approximately 30% for 1.5 mev betas. The system background is 575 ±20 counts per minute.

All samples were counted for gross beta activity as soon as possible after collection, and activity levels were computed at the time of count for the purpose of screening samples and delineating the effluent trajectory. These samples were then stored for five days to allow natural activity to decay. They were recounted at this time and again seven days later. Activity levels were then recomputed to end of collection from these two later counts. Several air samples showing levels of activity significantly above natural background were recounted frequently to obtain a decay curve. The curve obtained was then analyzed for best fit to the general equation $y=ax^b$. Based on an analysis of four such decay curves a $T^{-1.25}$ relationship was found to exist with a mean error of ±5%. This relationship was then used to correct all filters with high activity to end of collection.

All charcoal cartridges were gamma scanned by placing each cartridge directly on a 4" x 4" sodium iodide crystal coupled to a 400-channel pulse height analyzer set to view energies from 0 to 2 mev. Assuming no break in the prefilter, the activity on the cartridge should represent the gaseous fission products only (I^{131}, I^{132}, I^{133}, I^{135}, plus some Xe^{133} and Xe^{135}). Detection efficiency for this geometry is about 18% at 0.53 mev (I^{133}). The minimum detectable activity for each iodine isotope is taken to be about 200 picocuries total on the cartridge. Error estimates are such that values less than 1 picocurie per cubic meter of air collected (pc/M^3) are generally not reported. Since it is not possible to define duration of effluent passage at all locations, the reported

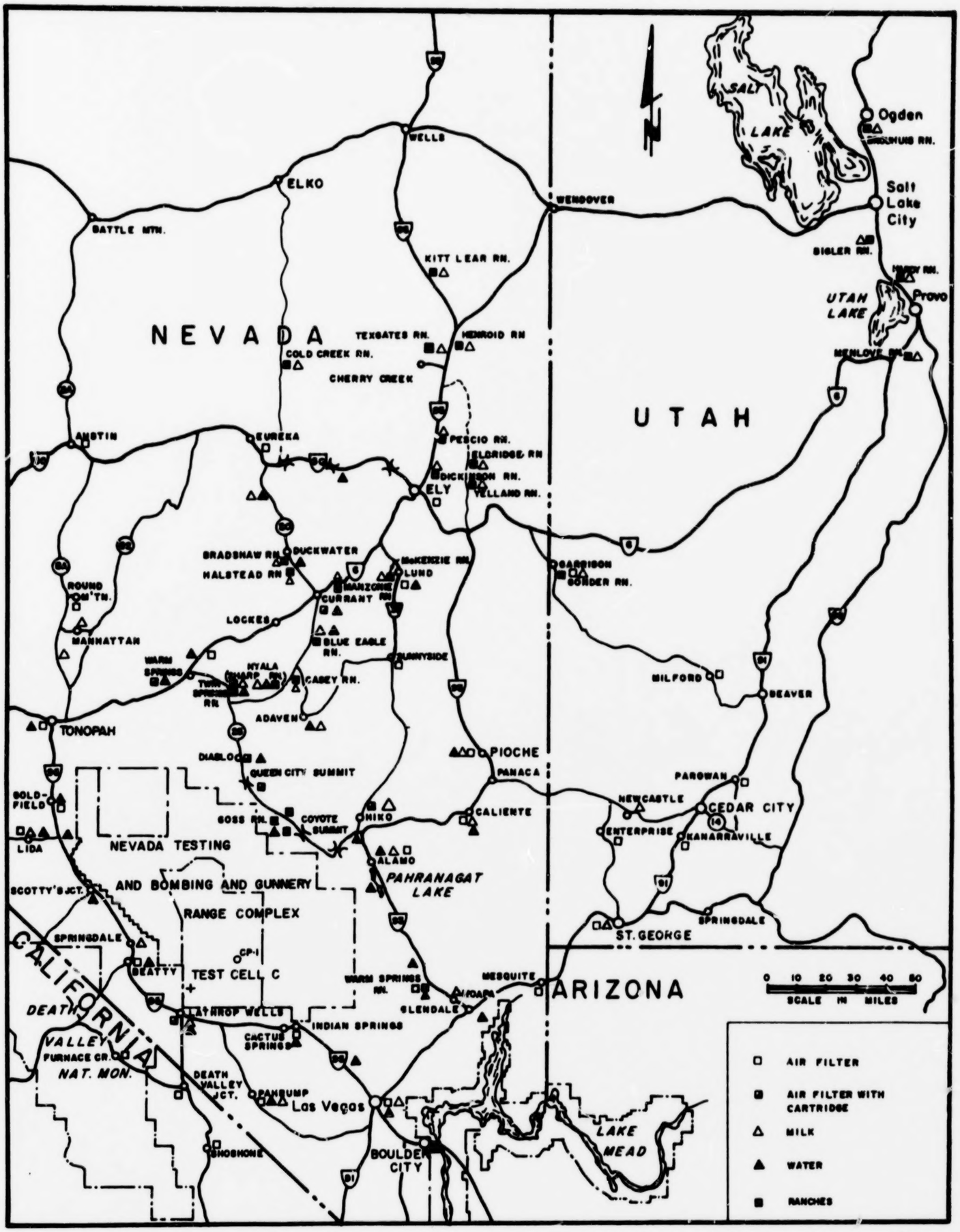

Figure 2. Environmental sampling locations for surveillance of the KIWI B4D test - May 13, 1964.

values given as pc/M^3 assume an average concentration over each entire sampling period.

Milk and Water Samples

After each release of activity from NRDS, milk samples are collected from dairies (processing plants), producing dairy farms, and farms producing milk for home consumption only (see Figure 2). Each sample is counted for 50 minutes. Due to the normally large sample load, no attempt is made to recount samples giving low positive values. For this reason the lower limit of detection for milk samples is taken to be 20 picocuries per liter (pc/l) at the time of count, and all results below that value are reported as<20 pc/l. The results are reported in Table 5. The error associated with reported values is ±20 pc/l or 10%, whichever is greater. All reported values are corrected to collection time.

All liquid samples are counted in 3.5 liter inverted well aluminum beakers which are placed on top of a 4"x 4" crystal coupled to a 400-channel pulse height analyzer. The detection efficiency for the 0.364 mev photopeak of I^{131} is 5.3%. A matrix technique is employed in computation to compensate for the interference due to the presence of other isotopes. The input to this matrix is variable, allowing for the simultaneous determination of any eight nuclides for which detection efficiencies and interference factors have been obtained. Actual computation is performed by an IBM 1620 computer.

Table 1. U.S. Weather Bureau observations at the NRDS on May 13, 1964.

SKY CONDITION: 10% scattered cloud cover VISIBILITY: unrestricted

UPPER AIR DATA AT JACKASS FLATS, NEVADA 1000 PDT, 5-13-64:

HGT (Ft.msl)	WIND (deg./kts)	PRESSURE (mb)	TEMP. (°C)	DEWPOINT (°C)	RELATIVE HUMIDITY (%)
SFC 3610	195/14	889	25.3	- 1.4	17
3820	195/17	882	23.8	- 2.7	17
3970	195/20	876	22.9	- 3.5	17
4000	195/23	875	22.5	- 3.1	18
4892	190/20	850	19.8	- 5.1	19
5000	185/17	846	19.3	- 4.2	20
6000	187/21	816	15.8	- 5.9	22
6726	186/22	795	13.5	- 6.7	24
7000	184/23	787	12.9	- 7.8	23
8000	180/25	759	10.7	-10.2	22
9000	191/26	733	8.7	-13.1	20
10000	204/24	706	6.4	-15.6	19
10220	205/21	700	6.0	-16.6	18
11000	205/18	680	5.3	MB	(13)
12000	207/12	654	4.3	MB	(13)
12172	204/12	650	4.1	MB	(13)
13000	201/12	632	2.1	MB	(14)
14000	194/13	607	- 0.7	MB	(14)
15000	195/15	584	- 3.5	MB	(14)
16000	196/17	562	- 6.4	MB	(15)
17000	199/17	541	- 8.9	MB	(15)
18000	213/18	520	-11.8	MB	(16)
18960	221/20	500	-14.5	MB	(16)
19000	229/22	---	----	----	---
20000	245/27	---	----	----	---

() Numbers in parentheses are the result of calculations based on assumed atmospheric conditions.

MB Motor Boating-dewpoint was below the limitations of the instrumentation.

--- Dashes indicate that data were not taken.

III. RESULTS

The intermediate power run (design power x 0.001) yielded no detectable activit off site. The full power run yielded activity in the off-site area. A summary of data collected off the test range complex is presented below. Weather conditions on the day of the test are presented in Table 1. Only slight changes in the conditions presented in this table were noted during the day.

A. GROUND MONITOR DATA

Peak gamma dose rates occurring off the test range complex are given in Table 2. The only populated location at which dose rates above background were detected was Diablo, where the peak net dose rate was 0.43 mr/hr. The locations in Table 2 were remonitored on May 14; however, no activity above background was detected.

Table 2. Peak dose rates off the test range complex on May 13, 1964.

LOCATION Azimuth & Distance from CP-1	Time of Peak Dose Rate (PDT)	Time Interval Monitored (PDT)	Net Peak Dose Rate (mr/hr)
Diablo 359°, 75 mi.	1410	1358 - 1615	0.43
Queen City Summit 5°, 52 mi. (Unpopulated)	1400	1350 - 1510	0.07
On Nyala Road 8 miles S. W. of Nyala 7°, 89 mi. (Unpopulated)	1505	1450 - 1545	0.13

B. DOSE RATE RECORDER DATA

The recorders at Diablo and Lund indicated radioactivity that could be associated with the effluent passage. The data are presented in Table 3.

Table 3. Dose rate recorder data on May 13, 1964.

LOCATION Azimuth & Distance from CP-1	Time of Peak Dose Rate (PDT)	Net Peak Dose Rate (mr/hr)	Time Interval In Which Dose Rate Above Bkg. Was Observed (PDT)	Estimated External Dose During Cloud Passage (mr)
Diablo 359°, 75 mi.	1410	0.36	1352 - 1504	<0.25
Lund 23°, 142 mi.	1711	0.028	1702 - 1744	<0.02

C. FILM BADGE DATA

Stationary and personnel film badges that were exposed off the test range complex during May indicated no exposure that could be associated with the KIWI test. All films collected north of the test range complex indicated no result above the threshold exposure (20 mr).

D. AIR SAMPLE DATA

Three of the samples taken off site contained fresh fission products. Analyses of the prefilters and charcoal filters are presented in Table 4.

E. MILK SAMPLE DATA

Milk samples collected from several ranches indicated the presence of radioiodine. As seen from Table 5 the iodine was found in an area north by northeast from the Nevada Test Site, and was detected as far as 220 miles from CP-1 (the NTS Control Point). No iodine was detected in the several samples obtained from Utah.

The TORY II-C intermediate power run took place on May 12, 1964, and the full power test was conducted on May 20, 1964. Air samples taken off-site following these events indicated no I^{131}, and it is believed that all iodine found in milk as reported in Table 5 is due to the KIWI B4D test. This is further substantiated by the relatively small release of fission products during the TORY tests that resulted in negligible dose rates (<0.05 mr/hr) off the test range complex.

F. WATER SAMPLE DATA

No evidence of fresh fission products was seen in twelve water samples taken from areas lying in the effluent's trajectory.

Table 4. Air sampling data.

I. STATION LOCATION			II. COLLECTION DATA								III. RADIOASSAY DATA					
				SAMPLING PERIOD							GROSS β COUNT		GAMMA PULSE HEIGHT ANALYSIS			
				BEGIN			END							ACTIVITY (pc/M³)		
STATION NAME	AZIMUTH (°)	DISTANCE (miles)	AIR VOLUME (M³)	Month	Day	Time	Month	Day	Time	COLLECTOR	CORR. TO:	AC-TIVITY (pc/M³)	CORR. TO:	I^{131}	I^{133}	I^{135}
Currant	13	125	960	5	13	07:00	5	14	07:00	P	ES	20	---	---	---	---
										C	---	---	ES	<1	3.5	ND
Diablo	359	75	462	5	13	07:15	5	13	16:37	P	ES	1500	---	---	---	---
										C	---	---	ES	ND	12	ND
Queen City Summit*	5	52	92.5	5	13	11:20	5	13	15:22	P	ES	400	---	---	---	---
										C	---	---	ES	<1	5.8	ND

*Unpopulated

P - glass fiber prefilter

C - charcoal filter

ES - end of sampling period

ND - not detected

--- not analyzed

Table 5. Milk sample analysis.

COLLECTION DATA		RADIOASSAY DATA		
LOCATION (Azimuth & Distance from CP-1)	DATE COLLECTED	ACTIVITY (pc/l) I^{131}	I^{133}	Cs^{137}
Alamo, Nevada 59°, 57 mi.	5/14/64	<20	<20	120
	5/16/64	<20	<20	130
	5/20/64	30	<20	110
	5/23/64	<20	<20	140
Hiko, Nevada 45°, 64 mi.	5/14/64	<20	<20	130
	5/16/64	<20	<20	120
	5/20/64	<20	<20	120
	5/23/64	<20	<20	110
Minnie Sharpe Ranch Nyala, Nevada 11°, 93 mi.	5/16/64	50	<20	180
	5/17/64	60	<20	220
	5/18/64	<20	<20	160
	5/18/64	50	<20	220
	5/21/64	<20	<20	210
	5/21/64	30	<20	180
	6/02/64	<20	<20	140
Casey's Ranch, Nevada 14°, 93 mi.	5/17/64	140	70	350
	5/18/64	100	<20	330
	5/20/64	70	<20	300
	5/22/64	<20	<20	190
	5/27/64	<20	<20	160
	6/04/64	<20	<20	120
Blue Eagle Ranch, Nevada 13°, 110 mi.	5/14/64	100	<20	640
	5/14/64	110	50	490
	5/16/64	120	70	380
	5/17/64	120	<20	370
	5/18/64	<20	<20	260
	5/20/64	40	<20	260
	5/21/64	40	<20	340
	6/02/64	<20	<20	160
Manzonie Ranch, Nevada 15°, 131 mi.	5/14/64	<20	<20	500
	5/17/64	<20	<20	360
	5/18/64	<20	<20	500
	5/19/64	<20	<20	440
	5/21/64	<20	<20	500
	5/22/64	<20	<20	360

Table 5. Milk sample analysis. (Cont.)

COLLECTION DATA		RADIOASSAY DATA		
LOCATION (Azimuth & Distance from CP-1)	DATE COLLECTED	ACTIVITY (pc/l) I^{131}	I^{133}	Cs^{137}
Bradshaw Ranch, Nevada 9°, 132 mi.	5/17/64	<20	<20	110
	5/18/64	<20	<20	80
	5/19/64	<20	<20	120
	5/21/64	<20	<20	100
	5/22/64	<20	<20	95
Halstead Ranch, Nevada 8°, 135 mi.	5/17/64	90	60	140
	5/18/64	110	<20	160
	5/19/64	100	<20	140
	5/21/64	<20	<20	110
	5/22/64	30	<20	140
	6/04/64	<20	<20	85
McKenzie Ranch, Nevada 23°, 142 mi.	5/17/64	<20	<20	250
	5/17/64	<20	<20	300
	5/18/64	<20	<20	320
	5/21/64	<20	<20	240
	5/22/64	<20	<20	290
Gonder's Ranch, Utah 40°, 173 mi.	5/19/64	<20	<20	130
Dickinson Ranch, Nevada 22°, 173 mi.	5/19/64	30	<20	170
	5/22/64	<20	<20	280
Yelland Ranch, Nevada 27°, 185 mi.	5/19/64	<20	<20	300
Pescio Ranch, Nevada 23°, 188 mi.	5/18/64	<20	<20	150
Eldridge Ranch, Nevada 25°, 196 mi.	5/19/64	<20	<20	440
Cold Creek Ranch, Nevada 5°, 204 mi.	5/19/64	<20	<20	200

Table 5. Milk sample analysis. (Cont.)

COLLECTION DATA		RADIOASSAY DATA		
LOCATION (Azimuth & Distance from CP-1)	DATE COLLECTED	ACTIVITY (pc/l) I^{131}	I^{133}	Cs^{137}
Henroid Ranch, Nevada 20°, 218 mi.	5/15/64	40	<20	160
	5/17/64	40	<20	170
	5/19/64	<20	<20	160
	5/20/64	<20	<20	180
	5/21/64	<20	<20	110
Tex Gates Ranch, Nevada 18°, 220 mi.	5/17/64	40	<20	220
	5/18/64	<20	<20	180
	5/19/64	<20	<20	170
	5/21/64	<20	<20	140
	5/22/64	<20	<20	180
Kitt Lear Ranch, Nevada 16°, 242 mi.	5/16/64	<20	<20	240
	5/18/64	<20	<20	200
	5/19/64	<20	<20	280
	5/22/64	<20	<20	300
Menlove Ranch, Utah 49°, 312 mi.	5/18/64	<20	<20	180
Bigler Ranch, Utah 43°, 330 mi.	5/18/64	<20	<20	140
Hardy Ranch, Utah 45°, 330 mi.	5/18/64	<20	<20	240
Brouhuis Ranch, Utah 38°, 360 mi.	5/18/64	<20	<20	120

IV. CONCLUSIONS

The KIWI B4D full power test yielded detectable, though not significantly large levels of radioactivity to the off-site area. The effluent covered an area roughly consisting of the Railroad Valley north of the test range complex between Queen City Summit and Duckwater. Resulting contamination was detected as far as 220 miles from CP-1 in the form of iodine in milk.

The peak I^{131} concentration of 140 pc/l following the test occurred at Casey's Ranch. Sampling of milk did not begin at Casey's Ranch until May 17, however, because Caseys had only one cow and it was being used to suckle mavericks until that date. Samples were taken at Nyala and Blue Eagle, in the vicinity of Casey's Ranch, on earlier days. The peak concentration at Casey's Ranch can be compared to the Federal Radiation Council Guides*. A daily intake of 100 pc, averaged over a year, is considered an acceptable intake level. Such an intake will yield a 0.5 rad/year dose to an infant's thyroid. A daily intake above that considered acceptable over a one year period could not have existed at Casey's Ranch for more than five days.

The iodine detected in samples collected off-site between May 13 and June 4 is believed to have originated from the KIWI B4D test and not from tests of the TORY II-C reactor made during the same period.

*Background material for the development of radiation protection standards, Report No. 2, Federal Radiation Council, September 1961.